DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

2. Claims 1, 3-9, 11-24, and 26-41 are rejected under 35 U.S.C. 103(a) as being unpatentable over George et al ("Surface Chemistry for Atomic Layer Growth") in view of Sandhu et al (US 6,313,035), Leskela et al (Journal De Physique IV for IDS filed 10/31/2007), and Suntola et al (US 6,015,590).

George et al discloses a method of atomic layer growth of SiO_2 using $SiCl_4$ and H_2O in an atomic layer epitaxial method. George et al also discloses deposition of other oxides such as Al_2O_3, SnO_2, TiO_2, ZrO_2, In_2O_3, and HfO_2 (pg 13122). George et al also discloses The surface functional groups also provide the technical means to alternate between various materials with

atomic layer control and form superlattices (pg 13131), this clearly suggests applicants' multicomponent mixed oxide thin film because applicant's teach that a multicomponent film is achieved by growing some other oxide onto the growth substrate between silicon dioxide growth cycles, note paragraph [0041] of the published specification in US 2004/0065253. George et al discloses repeating A and B reactions to form a desired layer (pg 13124), this reads on applicant's plurality of deposition cycles. George et al also teaches most ALP reactions are carried out in flow reactors (pg 13123), which clearly suggests wherein in each contacting steps, the silicon compound, the metal compound or oxygen source flows continuously from an inlet of the reactor to an outlet of the reactor.

George et al does not disclose a multicomponent thin film comprising silicon and a transitional metal. George et al discloses ALE for a variety of oxide materials including SiO_2 and Al_2O_3, SnO_2, TiO_2, ZrO_2, In_2O_3, and HfO_2.

In a method of forming a multicomponent oxide layer, note entire reference, Sandhu et al teaches a multi-component oxide layer comprises a mixture of a metal oxide and silicon oxide, specifically a silicon oxide and titanium oxide (claims 1 and 3). Sandhu et al also teaches the multi-component layer may be formed using CVD and may also be deposited using other processes (Abstract). Sandhu et al teaches the titanium silicon oxide layer may be used in a memory cell, as a capacitor oxide or other semiconductor devices or structures (col 8, ln 1-35). Sandhu et also teaches other combinations of dielectric and metals can be used. (col 8, ln 1-35).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify George et al by selecting silicon dioxide and Al_2O_3, SnO_2, TiO_2, ZrO_2, In_2O_3, or HfO_2 because a mixture of a metal oxide and a silicon oxide to form a useful multi-

component oxide layer which can be used to manufacture a useful semiconductor device, as taught by Sandhu et al (col 8, ln 1-65).

The combination of George et al and Sandhu et al does not teach a plurality of consecutive deposition cycles that each deposit only a $MSiO_x$.

Leskela et al teaches ternary metal oxides by ALE formed by pulsing the precursors in a sequence corresponding to the stoichiometry. (C5-946), this clearly suggest applicant's plurality of consecutive deposition cycles that each deposit only a $MSiO_x$ because only M, Si and O are used in the deposition, where M is A1, Si is A2 and O is B, based on the reactants taught by George et al.

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of George et al and Sandhu et al by using a 1:1 ratio to produce a ternary oxide having a desired stoichiometry, as taught by Leskela et al.

The combination of George et al, Sandhu et al and Leskela et al does not teach purging the reactor with an inert gas after each pulsing.

In a method of growing thin films using atomic layer epitaxy, Suntola et al teaches an interval between reactant pulses for evacuation of the entire gas volume in an apparatus during the interval between two successive reactant pulses and an inactive gas, this reads on applicant's inert gas, may be advantageously introduced to the reaction space during the evacuation (col 11, ln 20-40).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of George et al, Sandhu et al and Leskela et al by purging

the reactor with an inactive gas to prevent CVD film growth conditions, which are detrimental in an atomic layer epitaxy process (col 7, ln 50 to col 8, ln 20), as taught by Suntola et al.

As to the limitation "contacting the substrate in a flow type reactor", apparatus limitations, unless they affect the process in a manipulative sense, may have little weight in process claims. *In re Tarczy-Hornoch* 158 USPQ 141, 150 (CCPA 1968). In this case, the apparatus limitation does not affect the process in a manipulative sense, thus have been given little patentable weight. Furthermore, George et al teaches most ALP reactions are carried out in flow reactors (pg 13123), thus clearly suggests the use of flow type reactors.

Referring to claim 2, the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teaches the growth rate is dependent on the number of reaction cycles (pg 13127), this clearly suggests applicant's process is repeated to form a layer of a desired thickness.

Referring to claim 3-7, the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teaches using $SiCl_4$, $HfCl_4$ and H_2O as reactants (pg 13122).

Referring to claim 8-9, the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teaches deposition at 600 K (~327°C) (pg 13123).

Referring to claim 11-12, the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teaches groove material with flat portions (Figure 1).

Referring to claim 13, the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teach the deposition of dielectric films on trench or stacked capacitors for DRAM high storage memory (pg 13130) and Sandhu et al teaches forming a variety of semiconductor devices (col 8, ln 20-30); therefore forming on an electrode to form a semiconductor device would have been obvious to one of ordinary skill in the art.

Referring to claim 14-15, the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teaches a superlattice structure formed by alternating various materials, which include HfO_2, TiO_2, Al_2O_3 and ZrO_2 (pg 13122 and 13131).

Referring to claim 16-18, the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teaches SiO_2 gate oxides in MOSFET devices (pg 13121 col 1), deposition on a silicon surface (pg 13123 col 1) and the deposition higher dielectric gate oxide materials, such as TiO_2 and Al_2O_3 (pg 13130 col 2).

Referring to claims 19-20 and 40-41, the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teaches pulsing reactants to produce a desired stoichimetery, this clearly suggests using different ratios and stoichiometric films (Leskela et al pg C5-946).

Referring to claim 22, the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teaches forming silicon oxide by pulsing a silicon compound followed by H_2O, forming a metal compound by pulsing a metal compound followed by H_2O (George pg 13122) and purging the reactor between reactant pulses ('590 col 11, ln 30-40) to form a superlattice of various materials (pg 13131).

Referring to claim 24, the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teach self-limiting reactions (George et al Abstract).

Referring to claim 34-35, a cycle is a relative term and thus can be defined to include multiple layer depositions, i.e. a cycle can be defined to be two silicon oxide layer and two metal oxide layers. The combination of George et al, Sandhu et al, Leskela et al, and Suntola et al clearly suggest a cycle of Si→oxygen→metal→oxygen→Si→oxygen→metal→oxygen, which includes multiple silicon and first reactants a plurality of times in a cycle.

Referring to claim 36-39, the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teaches a similar method of alternating silicon and metal oxide deposition. The combination of George et al, Sandhu et al, Leskela et al, and Suntola et al does not teach the growth rate of the $MSiO_x$ is higher than the rate of ALD of the metal oxide and silicon oxide from which the metal oxide is formed. This limitation is directed to an effect of the process; therefore the effect of increased growth rate is expected because a similar method is expected to produce similar results.

3. Claim 10 is rejected under 35 U.S.C. 103(a) as being unpatentable over George et al ("Surface Chemistry for Atomic Layer Growth") in view of Sandhu et al (US 6,313,035), Leskela et al (Journal De Physique IV for IDS filed 10/31/2007), and Suntola et al (US 6,015,590) as applied to claims 1, 3-9, 11-24, and 26-41 above, and further in view of Lowrey et al (US 5,891,744).

The combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teach all of the limitations of claim 10, as discussed previously, except the thin multicomponent oxide is formed on a hemispherical grain structure.

In a method of monitoring the effects of hemispherical grains, Lowrey et al teach the capacitance of a polysilicon layer can be increased by increasing surface roughness of the polysilicon film and one type of polysilicon film, which maximizes a roughness of an outer surface is hemispherical grain polysilicon (col 1, ln 10-67). Lowery et al also teaches deposition of a dielectric on a hemispherical grain area, which forms a capacitor (col 4, ln 1-15).

The combination of George et al, Sandhu et al, Leskela et al, and Suntola et al teach the deposition of dielectric films on trench or stacked capacitors for DRAM high storage memory (George pg 13130 col 2). Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of George et al, Sandhu et al, Leskela et al, and Suntola et al by deposition the dielectric layer on a substrate having a hemispherical grain, as taught by Lowery et al, to enhance the capacitance of the capacitor.

Response to Arguments

4. Applicant's arguments filed 12/22/2009 have been fully considered but they are not persuasive.

Applicant's argument that George fails to suggest a process in which reactants flow continuously from an inlet to an outlet of the reactor is noted but not found persuasive. George et al teaches most ALP reactions are carried out in flow reactors (pg 13123), which suggest a process in which reactants flow continuously from an inlet to an outlet of the reactor. Applicant also alleges that George et al teaches long exposure times for as long as 72 minutes. George et al is directed to investigating the surface reactions and determining whether the reactions are self limiting (pg 13123), which required experiments of varying length, including experiments for as long as 72 minutes. However, George et al is not limited to these particular experimental embodiments. George et al teaches ALP deposition of SiO_2 (SiO_2[15, 17]) with reference to George et al Appl. Surf Sic 1994, herein "George (1994)." George (1994) clearly teaches saturation in 10 minutes at 600 K and complete half reactions in less than 1 min at 680 K (pg 463). Therefore, one of ordinary skill in the art at the time of the invention would clearly have not limited George

et al to long exposure times when exposure times of less than 1 min are known and referenced by George (1994).

Applicant's argument that the reported growth rate taught by George et al are for static fill reactors and there is no suggestion that the claimed growth rates could be obtained in a flow type reactor is noted but not found persuasive. Niinisto et al ("Synthesis of oxide thin films and overlayers by atomic layer epitaxy for advanced applications") teaches atomic layer epitaxy is a self limiting growth process wherein the film thickness is dependant only on the number of deposition cycles and allowing sufficient time is provided to complete each reaction cycle (Table 1). Therefore, as evidenced by Niinisto et al, an Atomic layer deposition process would be expected to produce the same growth rate, regardless of flow type or static fill reactors because the process requires saturation of the growth surface for each half reaction.

In response to applicant's argument that there is no suggestion to combine the references, the examiner recognizes that obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. See *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988)and *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992). In this case, Sandhu et al clearly teaches a mixture of metal oxide and silicon oxide to form multi-component oxide layers used to produce a variety of devices because the materials process dielectric constants that are sufficiently high to meets the design requirements for more advanced semiconductor devices (col 1, ln 10-65; col 3, ln 50-67; col 8, ln 1-35). The motivation to produce "useful devices" is sufficient reasoning to support an assertion of obviousness because

Sandhu et al teaches such devices are improved or otherwise would not be possible without the dielectric properties of a mixture of metal oxide and silicon oxide.

Applicant's argument that the Examiner has not considered the invention as a whole is noted but not found persuasive. The Examiner has considered the invention as a whole, as an atomic layer deposition process, wherein the features are obvious variations for the atomic layer deposition process and the Examiner has provide clear motivation to one of ordinary skill in the art for each modification; therefore the rejection is proper.

Conclusion

5. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Niinisto et al ("Synthesis of oxide thin films and overlayers by atomic layer epitaxy for advanced applications") teaches Atomic layer epitaxy can be used for deposition of ternary and quaternary oxides, and the ALE deposition of ZrO_2, TiO_2, HfO_2, Ta_2O_5, Al_2O_3, Y_2O_3, and the required precursor combinations of halide compounds and water (Niinisto Abstract and Table 2).

6. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after

the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to MATTHEW J. SONG whose telephone number is (571)272-1468. The examiner can normally be reached on M-F 9:00-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Michael Kornakov can be reached on 571-272-1303. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

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